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DOCUMENT-IDENTIFIER: US 6074569 A
TITLE: Stripping method for photoresist used as mask in Ch.sub.4 /H.sub.2 based reactive ion etching (RIE) of compound semiconductors

Brief Summary Text (9):
Apart from the traditional dry and wet methods directed specifically for stripping resist, there have been methods of removing sidewall polymers formed during the etching process. As noted above, and in a related fashion, etching processes may tend to polymerize the surface of the photoresist and thereby harden the resist. U.S. Pat. No. 5,567,271 generally describes an oxygen RIE plasma method for removing oxidized photoresist residue. But that disclosed method is concerned with adding hydrogen as a reducing material in a non-explosive fashion. In the context of removing sidewall polymers on deep etches (i.e., >5 .mu.m), a series of cycles having short etch plasmas followed by oxygen clean plasmas has been used. [J. E. Schramm, "Reactive Ion Etching of Indium-Based Compounds Using Methane/Hydrogen/Argon," Dissertation, University of California, Santa Barbara, p. 67 (1995)]. However, rather than being concerned with mask removal, such method is directed towards minimizing profile degradation.

Brief Summary Text (15):
Specifically, the improved method of the present invention includes flood exposing the patterned photoresist with a light and cyclically exposing the photoresist with a carbon based plasma and an oxygen plasma. The step of cyclically exposing occurs after the step of flood exposing. The step of flood exposing includes the steps of preventing polymerization and/or decomposing photoactive compounds in the photoresist, while the step of cyclically exposing includes the step of cyclically removing layers of the photoresist. In a particular embodiment of CH.sub.4 /H.sub.2 /Ar based RIE, the step of flood exposing occurs at a wavelength band between about 405 to 436 nm and at about 7 to 8 J/cm.sup.2. The CH.sub.4 /H.sub.2 /Ar is flowed at about 3/5/10 sccm, at a total pressure of about 3 mTorr, and an rf power of about 250 W over 3 minutes. The O.sub.2 is flowed at about 10 sccm, 20 mTorr, 250 W over 1 minute.

Brief Summary Text (18):
The present invention provides a method for stripping a photoresist used as a mask on a substrate. While the present invention is generally applicable in the context of reactive ion etching (RIE), the present invention contemplates that the improved method can be utilized in other contexts, such as electron cyclotron resonance (ECR), inductively coupled plasma (ICP) and magnetically enhanced reactive ion etching (MRIE). Additionally, while a preferred

embodiment is described with regard to a CH.sub.4 /H.sub.2 /Ar based method of RIE, the use of other plasmas are considered to be within the scope of the present invention.

Brief Summary Text (28):
Generally, the etching and ashing parameters are set based upon a balancing of substrate etching and hardening of the resist. It can be appreciated by those skilled in the art that as the CH.sub.4 /H.sub.2 /Ar exposure increases in density and/or time, the resist generally increases in hardness. Thus, the substrate etching parameters should be such that the resist does not become too hard to remove. In the embodiment of cyclical etching and cyclical ashing, the CH.sub.4 /H.sub.2 /Ar is preferably flowed at about 3/5/10 sccm, about 3 mTorr, with about 250 W rf power over about 3 minutes. The O.sub.2 is preferably flowed at about 10 sccm, about 20 mTorr, with about 250 W rf power over about 1 minute. With the above flow parameters, the resist etch rate is about 3000 to 5000 .ANG./min. Based on the resist etch rate observed. The substrate etch rate, with the above parameters, is about 100 .circle./min. Based on the resist etch rate observed it can be appreciated that the photoresist layer thickness should be adjusted for the desired amount of substrate etching. The number of required cycles can be determined with a given substrate etch rate and a known amount of substrate material to be removed. For example, with an etch rate of about 100 .ANG./min and 3minute CH.sub.4 /H.sub.2 /Ar cycles, the removal of about 600 .ANG. of substrate material would require 2 cycles.

Detailed Description Text (3):
conventional means. Standard lithography was done on a GaAs substrate made by AXT. The substrate was spin coated with AZ 1518 at 4000 rpm for 30 seconds. It was then soft baked on a hot plate at 100.degree. C. for 2 minutes. The substrate was then exposed with a mask at 210 mJ by an Ultratech 1100 stepper. A 351 developer by Shipley was used in a 1:5 volume ratio with water to develop the AZ 1518. A short descum was done in an MCS LF5 at 200 mTorr, 100 W for 2 minutes. With an MRC Aries MRIE, the substrate was then etched with CH.sub.4 /H.sub.2 /Ar at flows of 3/5/10 sccm at 3 mTorr, 250 W (-80 V dc) over 6 minutes. An MCS LF5 asher was used on the substrate at 250 W, 0.2 Torr over 5 minutes. After a PRS 1000 solution bath at about 100 to 120.degree. C. for 15 minutes, the substrate was rinsed with water. Microscopic examination in both standard and Nomarski phase contrast modes (.times.1000) showed significant photoresist residue around features.

Detailed Description Text (9):
Next, the substrates were subjected to an LF5 ash cleaning at 100 W, 0.2 Torr over 2 minutes. With the MRC Aries MRIE, the substrates were etched with CH.sub.4 /H.sub.2 /Ar flows of 3/5/10 sccm at 3mTorr, 250 W (-80V dc) over 3minutes. That was followed by an O.sub.2 flow of 10 sccm at 20 mTorr, 250 W (-90V dc) over 1 minute. The cycle was repeated twice. The LF5 oxygen barrel asher was then used on the substrates at 250 W, 0.2 Torr over 5 minutes. After a PRS 1000 solution bath at about 100 to 120.degree. C. for 30 minutes, the substrates were rinsed with water. An additional barrel ashing step was conducted at 250 W, 0.2 Torr over 5 minutes. By microscopic examination (.times.500) and Nomarski photographs, the substrates were found essentially devoid of any visual resist residue.

Current US Cross Reference Classification (6):

438/708

Current US Cross Reference Classification (7):
438/725

Current US Cross Reference Classification (8):
438/735

CLAIMS:

1. In a methane-hydrogen plasma based reactive ion etching process, a method of stripping essentially all of a photoresist on a substrate after said photoresist has been subjected to soft baking and patterned image exposure, comprising the steps of:

flood exposing said photoresist with a light to prevent polymerization that otherwise tends to harden said photoresist and to enable decomposition of photosensitive compounds in said photoresist; and

cyclically etching said photoresist by exposure to an oxygen plasma and said methane-hydrogen plasma, said methane-hydrogen plasma exposure causing a hardening of said photoresist and being separate from said oxygen plasma exposure, the step of cyclically etching occurring after the step of flood exposing.

8. In a methane/hydrogen/argon reactive ion etching process, a method of stripping essentially all of a photoresist on a substrate after said photoresist has been subjected to soft baking and patterned image exposure, comprising the steps of:

flood exposing said photoresist with a light to prevent polymerization that otherwise tends to harden said photoresist and to enable decomposition of photosensitive compounds in said photoresist;

oxygen ashing said photoresist after the step of flood exposing;

cyclically exposing said photoresist to said methane/hydrogen/argon plasma and an oxygen plasma, said methane/hydrogen/argon plasma exposure causing a hardening of said photoresist, the step of cyclically exposing occurring after the step of flood exposing.

14. The method of claim 13, wherein the step of plasma exposing with said methane/hydrogen/argon occurs over about 3 minutes at about 3 mTorr and 250 W.

16. The method of claim 15, wherein the step of plasma exposing with said oxygen occurs over about 1 minute at about 20 mTorr and 250 W.

17. The method of claim 8, wherein the step of cyclically exposing comprises the step of exposing said photoresist with alternating exposures of said methane/hydrogen/argon plasma and said oxygen plasma.

18. The method of claim 8, wherein the step of cyclically exposing comprises the step of continuously exposing said photoresist with said

methane/hydrogen/argon plasma.

19. The method of claim 8, wherein the step of cyclically exposing comprises the steps of continuously exposing said photoresist with said oxygen plasma and cyclically exposing said photoresist with said methane/hydrogen/argon plasma.